

## **Project X Front End R&D Program - PXIE**

January 11, 2012

We are planning a program of research and development aimed at integrated systems testing of critical components comprising the front end of the Project X linac at Fermilab. This program is being undertaken as a key component of the larger Project X R&D program. The successful completion of this program will validate the concept for the Project X front end, thereby minimizing the primary technical risk element within Project X. Successful systems testing will also demonstrate the viability of novel front end technologies that will find applications beyond Project X in the longer term. Integrated systems testing, known as the Project X Injector Experiment (PXIE), will be completed over the period FY12-16.

### **Mission Goals**

Validate critical technologies required to support the Project X Reference Design concept.

- Provide a platform for demonstrating operations of Project X front end components at full design parameters
- Integrated systems test goals:
  - 1 mA average current with 80% bunch-by-bunch chopping of beam delivered from the RFQ
  - Efficient acceleration with minimal emittance dilution through at least 15 MeV

### **Scope**

The scope of PXIE includes:

- CW H<sup>-</sup> source delivering 5 mA at 30 keV
- LEBT with beam pre-chopping
- CW RFQ operating at 162.5 MHz and delivering 5 mA at 2.1 MeV
- MEBT with integrated wide band chopper and beam absorbers capable of generating arbitrary bunch patterns at 162.5 MHz, and disposing of up to 5 mA average beam current
- Low beta superconducting cryomodules capable of accelerating 1 mA of beam to at least 15 MeV
- Associated beam diagnostics
- Beam dump capable of accommodating 1 mA at full beam energy for extended periods.
- Associated utilities and shielding

### **Rationale**

A concept for delivery of high power, high duty factor, beam to multiple experiments with differing beam structure requirements is incorporated into the Project X Reference Design. This capability is unique among high power proton facilities either operating or under development

anywhere in the world. The concept is based on a fast programmable beam chopper (aka wideband chopper) integrated into the linac front end, capable of removing bunches spaced at 6 nsec in arbitrary patterns and paired with a transverse rf deflecting cavity to send beam to three different experimental areas at 3 GeV. While the utilization of rf deflection to support multiple experiments has already been demonstrated at the CEBAF facility at TJNAF, the wideband chopper is a unique device currently beyond the state of the art.

The delivery of multi-MW CW proton beams to 3 GeV requires a linac front end capable of efficient acceleration of low- $\beta$  beams with minimal halo formation. The utilization of superconducting accelerating structures in this regime is unique and presents significant technical challenges. In addition the outlined capabilities are critical to establishing routine operations meeting extremely stringent beam loss criteria – typically less than 1 W/m. At 3 GeV this translates into a fractional beam loss of  $<3 \times 10^{-7}/\text{m}$ . The initial stage of acceleration, utilizing accelerating structures at  $\beta=0.1$  and  $0.2$  up to 40 MeV, is crucial in meeting this performance goal.

The purpose of PXIE is to demonstrate that the technologies selected for the Project X front end can indeed meet the performance requirements established in the Reference Design, thereby mitigating the primary technical risk element associated with Project X. This goal would ideally be achieved in advance of Project X construction so that results can be properly reflected in the final Project X machine.

### Plan

PXIE is part of the Project X R&D program and its development of PXIE will be coordinated from within the Project X organization. However PXIE will require close cooperation with the SRF and General Accelerator Development programs at Fermilab. The effort will be provided initially by Fermilab, LBNL, ANL, and SLAC with opportunities for collaboration with Indian colleagues who are developing similar systems for their ADS programs. Opportunities to integrate additional collaborators with similar interests will be pursued.

A simple shielded enclosure connected to the newly constructed Cryomodule Test Facility (CMTF) at Fermilab has been identified as the preferred location. This location has the following positive attributes:

1. Easy access to a cryogenic system with adequate capacity
2. Adequate length (at least 40 m)
3. Easy access to adequate AC Power, LCW, ICW, etc
4. Suitable location for a control room and office space
5. Ease of constructing and providing the required shielding

### Timeline and Resources

We are in the initial stages of planning for PXIE. The overall schedule will be determined by consideration of the following:

- Available funding: The bulk of the funding will come from Project X R&D, augmented by SRF and GAD program funding.
- Project X schedule: At the moment we do not have a schedule for Project X. However, current Project X planning assumes a construction start in the FY2016-17 time frame.

For planning purposes the following schedule has been established:

Jan 2012	Complete PXIE design layout and preliminary cost/schedule estimates
Nov 2012	Complete RFQ design and begin fabrication
Jun 2013	Ion source and LEBT received at Fermilab; installation begins;
Apr 2014	Start RFQ high-power testing without beam;
Nov 2015	Beam delivered to the end of MEBT with nearly final parameters (2.1 MeV, 1 mA CW, 80% arbitrary chopping) Begin installation of beta=0.1 and beta=0.2 CMs
Oct 2016	Beam to 15 MeV with nearly final parameters (1 mA CW, 5 mA peak, arbitrary bunch chopping)